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SMD Operations Procedures Manual

8.1.3.23 CRYOGENIC OPERATION OF AGS COLD SNAKE MAGNET IN B902

Text Pages 1 through 12

Hand Processed Changes

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Revision 00

Approved

Signature on File
Division Head

3/16/05
Date

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SMD-OPM 8.1.3.23
Category B

Revision 00
March 9, 2005

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8.1.3.23 Cryogenic Operation of AGS Cold Snake Magnet in B902

1.0 Purpose

This procedure provides instruction on the following operations of testing the AGS Cold Snake Magnet in B902.

- Pump & Purge the AGS Cold Snake Magnet.
- Cooldown to 80 K using Liquid Nitrogen
- Cooldown to 4.5 K using Liquid Helium
- 4.5 K operation
- Warmup

2.0 Responsibilities and Scope

Operator is responsible for the cryogenic operations associated with testing the AGS Cold Snake magnet.

- 2.1 After the cold snake magnet is installed in B902, the operator needs to connect the supply line and the return lines.
- 2.2 The operator is responsible for the pump & purge operation to make sure the system is clean and leak tight.
- 2.3 The operator is responsible for cooling the magnet to 80 K using liquid nitrogen. It needs an estimated 1,200 Liter of liquid nitrogen and 24 hours, at a rate of ~ 50 L/hour.
- 2.4 After the magnet reaches 80 K, the operator needs to use helium gas to blow out liquid nitrogen in the snake magnet and keeps those lines under vacuum.
- 2.5 The operator is responsible to cool the magnet from 80 K to 4.5 K using liquid helium and the 4 cryocoolers. This process needs approximately 660 L of liquid helium and expect to take about 12 hours. The four cryocoolers provide little cooling at the beginning of 4.5 K cooldown, but should eventually provide necessary cooling for steady state operation at 4.5 K
- 2.6 During initial test, several magnet quenches and rapid pressure rises are expected. The operator is responsible to prevent overpressure by venting the helium gas to recovery tanks. Although the system is protected with safety relief. It is import to save helium after a quench.

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- 2.7 After a quench, the Snake Magnet will reach about 12 K. The operator is responsible for cooling the magnet to 4.5 K using liquid helium. During quench and recovery, there is no interruption on operation of the cryocoolers.
- 2.8 At the conclusion of the test, the operator is responsible for warming up the magnet to room temperature using the electric heater inside the Snake Magnet with a small amount of helium flow to keep the magnet temperature uniform.
- 2.9 The operator is responsible for the control of environmental aspects as defined in course number AM-ENV-F56.

3.0 Prerequisites

- 3.1 Operator shall be instructed by a supervisor or designee. Instructions shall include:
 - 3.1.1 The operation of vacuum pump, 1000 gallon liquid helium storage dewars and the LN2 system.
 - 3.1.2 The Process Control PC workstation for the Snake Magnet.
 - 3.1.3 Operation of Sumitomo Heavy Industries, SHI, cryocoolers Model RDK-408.
 - 3.1.4 Venting helium after a magnet quench.

4.0 Precautions

- 4.1 Transfer liquid helium to Snake Magnet involves pressurizing the liquid storage dewar in use. The operator shall not over pressure the liquid storage dewar.
- 4.2 Ensure personnel near unit are authorized, or accompanied by authorized personnel.

5.0 Procedure

5.1 Pump & Purge Cold Snake Magnet

- 5.1.1 Make sure the insulating vacuum of the snake magnet is established, below 10^{-4} Torr.
- 5.1.2 Make sure the nitrogen and helium lines are properly connected to the Cold Snake Magnet.

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- 5.1.3 The operator needs to pump the helium side using the vacuum pump for the Magnet Test Dewars, and the nitrogen side using a portable vacuum pump.
- 5.1.4 Switch pressure read out to Magnet Test Dewar 2 by turning Whitey valve located behind the control panel near the distribution header. (Connected to the vent line of the Snake Magnet)
- 5.1.5 Make sure all valves in the supply and the return headers of Magnet Test Dewars are closed.
- 5.1.6 Open H5467A and H5466A on the Snake Magnet.
- 5.1.7 Open AOV18
- 5.1.8 Crack open vacuum pump valve V4 to pump on the helium side of the Snake Magnet.
- 5.1.9 After the pressure decreases somewhat, fully open V4.
- 5.1.10 The magnet pressure, as shown on PI0189, should reach -30" in about 10 minutes.
- 5.1.11 When the pressure is less than 200 micron, on the vacuum gauge VI0175, close V4.
- 5.1.12 Crack open HE16 to fill the helium side with clean helium.
- 5.1.13 After the 1st pump down, leak check shall be performed for all piping connections.
 - 5.1.13.1 Crack open MOV4 (warmup) to fill Snake Magnet to 7 psi on PI0189.
 - 5.1.13.2 Use Leak Teck to check all joints on lines specifically connected to the Snake Magnet for this test.
- 5.1.14 Repeat steps 8 through 12 three times.
- 5.1.15 Pump & purge for the helium side of the Cold Snake Magnet is completed and the magnet is connected to low pressure clean helium.

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- 5.1.16 The pump and purge for the nitrogen side of the Snake Magnet is to be performed using a portable vacuum pump.
- 5.1.17 To pump and purge the nitrogen side, close both valves at supply (N400a and N400b) and vent (N402a and N402b) line for the nitrogen system.
- 5.1.18 Use the portable vacuum pump to pump on the line through V300M.
- 5.1.19 After the vacuum is established (below 200 micron), close V300M (inlet to the portable vacuum pump).
- 5.1.20 Fill the line with helium through a bottle, and repeat pump one more time.
- 5.1.21 The Pump & Purge is considered complete.
- 5.1.22 The nitrogen system for the Snake Magnet is ready to accept nitrogen flow.

5.2 Cooldown to 80 K for Cold Snake Magnet

- 5.2.1 Make sure the Cold Snake Magnet has been properly pumped and purged for the helium side and lines for liquid nitrogen.
- 5.2.2 The 80 K cooldown is performed using LN2 directly from the B902 LN2 header with N2 gas vented outside B902.
- 5.2.3 Open N400a, N400b, N402a and N402b.
- 5.2.4 Manually open the LN2 supply valve HE6 on the LN₂ heat exchanger above PAT refrigerator (this is the tapping point) to flow through LN2 lines to the magnet and the shield.
- 5.2.5 On the PC work station, monitor cooldown rate from temperature sensor TT1052N and TT1053N on the return side.
- 5.2.6 The temperature TT1052N and TT1053N will decrease with time. It takes about 24 hours for the Snake Magnet to reach 80 K. The cooldown rate is approximately 10 K per hour.
- 5.2.7 Close liquid nitrogen supply valve HE6.

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5.3 Pump on the LN2 lines inside the Cold Snake Magnet (prior to 4.5 K cooldown)

- 5.3.1 Close valves N400a and N400b on LN2 supply, and N402a and N402b on N2 vent line.
- 5.3.2 Blow the nitrogen out of the 80 K cooldown lines using warm bottle helium. Set regulator on the bottle for ~ 5psi. Open M412H and M414H.
- 5.3.3 After 2 – 3 minutes. Close M412H and M414H.
- 5.3.4 Disconnect the N2 vent line and connect return line to the suction of vacuum pump.
- 5.3.5 Turn on portable vacuum pump and open V300M.
- 5.3.6 Observed vacuum on VT and PT
- 5.3.7 After the vacuum is established (below 200 micron), close V300M
- 5.3.8 The LN2 lines must be kept at good vacuum during the entire test to eliminate potential undesirable heat load.

5.4 Coolodwn to 4.5 K and 4.5 K Operation for the Cold Snake Magnet

- 5.4.1 After the magnet reaches 80 K and vacuum is established in the 80 K cooldown lines, one can proceed with 4.5 K cooldown. Liquid helium in conjunction with the four cryocoolers will be used.

Note: During the 4.5 K cooldown, helium gas will return to the low pressure clean helium system in B902 through AOV19, AOV23 and Moore Controller.

- 5.4.2 Turn on cooling water to the compressors of the cryocooler if it is not on already. Make sure the helium is properly charged for the cryocoolers, Turn on all four cryocoolers from PC workstation. The discharge pressure of the compressors should be between 220 and 250 psi.
- 5.4.3 Make sure all valves in the supply and the return headers of Magnet Test Dewars are closed.
- 5.4.4 Open AOV 18, AOV22 and MOORE CONTROL VALVE to the low pressure return.

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- 5.4.5 Set up valves for precooling transfer line to the Snake Magnet. Open H5468A. Close H5467A and H5466A.
- 5.4.6 Select either storage dewar 1 or 2 to provide liquid helium.
 - 5.4.6.1 For storage dewar 1 and PAT is running, close return valve HE34 slightly to increase pressure in storage dewar 1 to 7 psi.
 - 5.4.6.2 For storage dewar 1 and PAT is not running, use warm helium to pressure storage dewar 1 to 7 psi by opening H0245M and pressure regulator PR0261. Close HE34 all the way.
 - 5.4.6.3 For storage Dewar 2 and HEUB is running, close return valve X1154M slightly to increase pressure in storage dewar 1 to 7 psi.
 - 5.4.6.4 For storage Dewar 2 and HEUB is not running, use warm helium to pressure storage dewar 1 to 7 psi by opening H0279M and pressure regulator PR0296. Close X1154M all the way.
- 5.4.7 To get ready for transfer liquid helium to the Snake Magnet, open the helium supply valve on the storage dewar.
 - 5.4.7.1 For liquid Storage Dewar 1, open AHE32.
 - 5.4.7.2 For liquid Storage Dewar 2, open AHE43.
- 5.4.8 Monitor TT1062H from workstation. When TT1062H reaches 80 K, open H5467A and close H5468A.
- 5.4.9 On the PC workstation, monitor cooldown from temperature sensor TT1036 which measures the helium temperature after cooling the Snake Magnet.
- 5.4.10 It will take about 12 hour for the Snake Magnet to reach 4.5 K. Liquid level LI30H or LI31H will occur after. The cooldown rate is estimated at 6 to 7 K per hour.

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- 5.4.11 Once liquid level becomes stabilized, LI30H and LI31H at ~ 95%. The supply valve H5467A can be closed and the Snake Magnet cooled by the 4 cryocoolers only. Note: if the cryocoolers is not able to keep the magnet cold, then Lhe make up must be used to add liquid to the magnet.
- 5.4.12 The Magnet is ready for test.
- 5.4.13 A major test for the magnet is quench. The magnet test operator informs the cryogenic operator prior to a magnet quench. When the magnet quenches, the pressure inside the Snake Magnet will increase.
 - 5.4.13.1 Get ready for venting helium through H1001A, open the isolation valve located immediately downstream of H1001A. Note: Valves AOV24 and AOV25 are lock open by removing air for this test. Immediately after a quench, the operator shall open H1001A manually to dump helium to recovery tank. Close H1001A when the pressure reduced to 15 psi.
- 5.4.14 To cool the Snake Magnet to 4.5 K after a quench,
 - 5.4.14.1 Open H5468 to precool the transfer line.
 - 5.4.14.2 Close H5467A and H5466A.
 - 5.4.14.3 Close H5468A after TT1062H reads below 10 K
 - 5.4.14.4 Open bottom fill valve H5467A to cool the magnet.
 - 5.4.14.5 Continue until liquid level is established on LI30H and LI31H.
- 5.4.15 At the end of the 4.5 K test, close liquid helium supply valve on the selected storage dewar.
- 5.4.16 Vent helium in the cold transfer line and close the cold helium supply valve on distribution line.
 - 5.4.16.1 For liquid storage dewar 1 or 2, cold helium supply valve can be closed right away by opening HE37 to vent helium for about 20 minutes.
- 5.4.17 Reduce pressure in liquid helium storage dewar to 5 psi.

5.5 Warmup for the Cold Snake Magnet

Note: There is a 2 KW electric heater in the Cold Snake Magnet. Helium flow is

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to be used to keep the temperature uniform in the magnet. The maximum temperature differential in the magnet is about 50 K. Care must be taken to prevent coil over temperature. Turn off heater when the coil reaches 250 K as indicated by TT1037. The maximum pressure of helium shall be less than 10 psi during warmup.

5.5.1 Stop cryocoolers from the PC workstation. Turn off water to the compressors of the cryocoolers.

5.5.2 Make sure valves in the supply header

AHE10 - liquid helium supply,
MOV4 – warmup supply, and
MOV2 – 100 K cooldown supply
are closed.

5.5.2 Make sure valves in the return header

HE16 – to dirty gas bag, and
V4 – to vacuum pump
are closed.

5.5.3 Open AOV24 (subcool) and MOORE CONTROL VALVE low pressure return.

5.5.4 Crack open warmup valve MOV4. The upstream valve MOV219 or MV217 is preset for normal warmup flow rate. Adjust the pressure to about 5 psi.

5.5.5 Watch LI30H and LI31H from the PC workstation. Liquid helium will boil off rapidly. Make sure the boil-off does not upset the compressor system in B902.

5.5.6 After liquid helium boiled off, turn on the electric heater in the Snake Magnet.

5.5.7 Watch temperature TT1036 on the PC workstation. The temperature increases with time. It takes about 15 hours for the Magnet to reach room temperature.

5.5.8 Turn off electrical power to the warmup heater (in the Cold Snake Magnet).

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5.5.9 Close warm up supply valve MOV4.

5.5.10 The purpose of warm up is to remove the magnet. Therefore all supply and return valves must be closed.

5.5.11 Close AOV24 and MOORE CONTROL VALVE. Close AOV18, AOV22 AND AOV20.

5.5.12 Make sure all supply valves and return valves are closed. Vent residual helium from the dewar.

5.5.13 The Snake magnet is ready for disconnect.

6.0 Documentation

6.1 Documentation is kept in 902 Cryogenic Control Room.

7.0 References

7.1 BNL Drawing, P&I D, AGS Cold Snake Magnet, D18-M-4631

7.2 Operation Manual, SRDK Series Cryocooler, Sumitomo Heavy Industries, Ltd.
Manual Number: CD32ZZ-063A

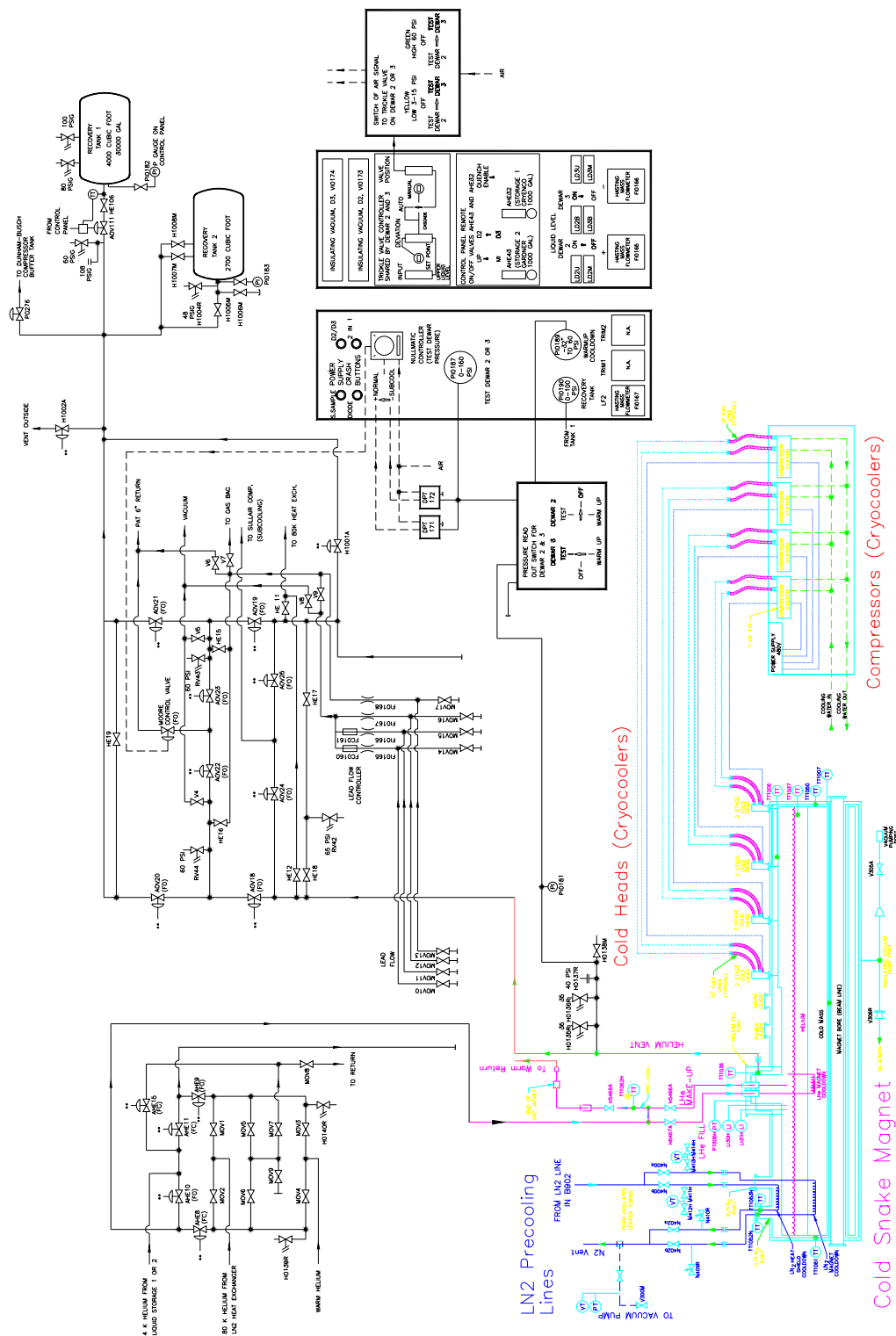
7.3 BNL Drawing, P&I D 902A, Magnet Test Dewar 2 & 3, RD 1215549.

7.4 BNL Drawing, P&I D 902A, Liquid Helium Storage Area, RD 12155451.

8.0 Attachments

8.1 Flow diagram for testing Cold Snake Magnet in B902.

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